

LABORATORY TESTS SHOWING THE EFFECT OF DDT ON SEVERAL IMPORTANT PARASITIC INSECTS

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During the summer of 1945 the author was given the opportunity to study the effect of DDT, a new touch insecticide, on certain parasitic insects, particularly those attacking the oriental fruit moth (*Grapholitha molesta* (Busck)) and the strawberry leaf roller (*Ancylis comptana fragariae* (Walsh and Riley)). The project was a cooperative set-up between the U. S. Bureau of Entomology and Plant Quarantine and the Department of Entomology of the Ohio Agricultural Experiment Station at Wooster, Ohio. The author is indebted to N. D. Blackburn for assistance in obtaining some of the parasites and for observations made when the author was absent, to H. W. Allen of Moorestown, N. J., for shipments of living specimens of *Macrocentrus ancylivorus* Roh. and to C. F. W. Muesebeck for final determination of the species of parasitic insects tested.

The following is a brief summary of the many tests conducted in the laboratory to determine how toxic a dry deposit of DDT spray on foliage might be to parasitic adult insects that visited the treated leaves. The tests were designed to determine the strength of DDT and the exposure time required to kill, as well as the toxicity of deposits one to nine weeks old on orchard-sprayed foliage. The exploratory nature of the project gave the writer an opportunity to test various parasitic and predacious insects, however, this report is restricted to a summary of the results obtained from numerous tests with five parasitic species, namely, one braconid, *Macrocentrus ancylivorus* Roh., an important parasite of the Oriental fruit moth, reared from field-collected strawberry leaf rollers and from the potato tuber worm, (*Gnorinoschema operculella* (Bell)), in the laboratory; two ichneumonids, *Cre-mastus cookii* Weed and *C. forbesi* Weed reared from field-collected strawberry leaf rollers, and two tachinids, *Nemorilla floralis* (Fall.) reared from field-collected strawberry leaf rollers and *Archytas apicifera* (Walk.) collected on sweet clover.

The DDT (2, 2-bis (p-chlorophenyl)-1, 1, 1-trichloroethane) used was prepared by du Pont under the trade name "Deenate, 25W." This wettable powder contained 25 per cent DDT. Consequently in all the formulae employed, 4 parts were used for each single unit of DDT stated in the dosages named. Three methods of testing were employed, namely, small vials for walk-tests, large vial tests, and small wood-gauze-celluloid cage (4" x 4" x 6") tests. The cage tests were most satisfactory; hence, most of the results reported are from exposures made in the cages.

SMALL-VIAL TESTS.—For testing parasites individually, especially for short exposures not exceeding 10 seconds, the small-vial walk-testing procedure was very satisfactory. In this method a single adult was placed in a clean 15 x 80 mm. shall vial. The open end of the vial was inserted in a glass tube 15 cm. long lined in the center with 5 cm. of sprayed (dry) peach foliage. By proper orientation toward a light source (a north window) the adult was induced to walk over the sprayed foliage and into a clean 15 x 80 mm. shell vial at the opposite end. This contained a small drop of honey-agar. After the adult had entered, the vial was removed and stoppered with a moistened gauze covered cotton plug. The act of walking over the sprayed foliage required 2 to 10 seconds. When tested individually in lots of 10 replicated several times, the results with adults of *M. ancylivorus*

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livorus showed 60 to 90 per cent kill within 36 hours after the adults had walked over and touched a dry deposit of DDT on a peach leaf that had been sprayed with a 1-1000 water suspension of the material (i.e., 1 gram of DDT in 1000 cc. of water). In similar tests *Cremastus cookii*, *C. forbesi* and *Nemorilla florialis* were unaffected by the same spray, also sprays containing 1 part of DDT to 5000 and 10,000 parts water produced no kill.

LARGE-VIAL TESTS.—Numerous large-vial (1" x 8") tests were conducted with the various parasites. The results in most cases were very similar to the small cage tests; consequently, they will not be reviewed in this report. One or two facts, however, should be mentioned. A 10-minute exposure of *M. ancylivorous* to DDT sprayed at the rate of 1-1000 killed all the adults, while 10 minutes exposure to DDT at the rate of 1-5000 to 1-10,000 produced only 60 to 70 per cent kill. In general, the percentage killed in the large vials was not as high for a given exposure or dosage as similar tests in the cages. This may have been due to the high humidity present in the vials, especially where leaves were present for the duration of the test.

CAGE TESTS.—The cages used were 4" x 4" x 6". The ends, top and bottom were made of wood; the back was covered with gauze, and on the front was a sliding door made of wood and celluloid. These cages resembled closely the shipping container described previously (Peterson, 1934). The principal differences were that one long side of the cage served as a bottom, the sliding door was covered with celluloid, the 2 dram homeopathic vial containing water and dental cotton was fastened in a horizontal position to the inner surface of the left end, and the piece of cardboard smeared with a honey-agar mixture was tacked to the rear inner surface of the top board. In each cage either a sprayed or an unsprayed peach twig possessing five to seven leaves and held in a 3-dram homeopathic, cotton-stoppered, water-filled vial was inserted in such a manner that some of the leaves were in contact with the gauze side of the cage which faced the outside light source. All cages were cleaned thoroughly and swabbed with 95 per cent ethyl alcohol before they were used for succeeding tests. In each cage was placed fresh water, honey-agar food, and the test peach twig, before the 10 to 25 or more adults were introduced through the cork-stoppered opening. The twig was kept in the cage for the duration of the test. In most tests more females than males were used when it was possible to determine the sexes readily. All cages were placed on the wide sill of a north window which was kept open day and night. The temperatures within the cages agreed closely with those recorded at the Ohio Agricultural Experiment Station weather station. Usually final records were taken 36 to 48 hours after the adults were introduced. In most tests the mortality in the check cages was less than 10 per cent. If the mortality in the check cages exceeded 25 per cent, the series was considered unsatisfactory. The cages were used primarily for two types of testing, namely, (a) the determination of the dosage of DDT required to kill and (b) the effect on the toxicity of DDT-spray deposited on the foliage of peach trees which remained exposed to the weather in the orchard until used.

In the dosage tests, 10 to 25 (or more) adults, usually less than 3 days old, were used in each cage. The number employed depended upon the supply available. Two series of dosages were employed: (a) If the supply of parasites was large, dosages of DDT at the rate of 1-10,000, 1-20,000, 1-30,000, 1-40,000, 1-50,000 and 1-100,000 water suspensions were used. (b) When the parasite supply was low, dosages of 1-10,000, 1-50,000 and 1-100,000 were used. In all the tests, the peach foliage was sprayed at the specified dosages and allowed to dry thoroughly before the twigs were placed in the cages. All five species of insect parasites named previously were subjected to the dosage tests. In most cases, especially among the species of Hymenoptera, all tests were replicated several times.

RESULTS OF DOSAGE TESTS.—In all of the experiments with all five species of parasites, a dosage of DDT at the rate of 1-10,000 killed 100 per cent, except in one replication with *C. forbesi* where 90 per cent were killed. In a number of series of tests, dosages as low as 1-50,000 killed 100 per cent, especially in tests with *M. ancyliivorus* and *A. apicifera*. Also, in some of the tests with *M. ancyliivorus*, 60 per cent of the adults were killed at a dosage of 1-100,000. Among the Hymenoptera, *M. ancyliivorus* proved to be somewhat more susceptible to DDT than the species of *Cremastus* tested. This was most evident at dosages more dilute than 1-30,000. It was observed among the Hymenoptera that males and females were equally susceptible to DDT.

The age of the DDT deposit on foliage appeared to effect the toxicity of the material. This was indicated strongly in some of the series A dosage tests where sprayed leaves of a given test were held for 3 to 5 days and used again in the same cages with the same species of parasite. In the repeat tests with *M. ancyliivorus* and *C. forbesi* the percentages of kill were lower at all dosages less than 1-20,000 than in the first tests with the same sprayed leaves. This indicates strongly that some deterioration in the toxicity of the DDT on the sprayed leaves took place during the 3 to 5 day holding period.

TABLE I

TABLE SHOWING THE EFFECT OF AGE-OF-SPRAY-DEPOSIT ON THE TOXICITY OF DDT TO
M. ancyliivorus

Dosage 1 part DDT to 1000 parts of water

Cage	Date Sprayed	TESTED 7/31, 70-95° F., 50 PER CAGE				TESTED 8/22, 61-74° F., 25 PER CAGE			
		Age in Days of Deposit	Inches of Rain*	No. Dead 35 Hr.	Pct. Dead	Age in Days of Deposit	Inches of Rain*	No. Dead 40 Hr.	Pct. Dead
A	Check	No DDT	3.80 (12)	10	20	No DDT	5.17 (16)	3	12
B	6/19	42	3.80 (12)	6	12	64	5.17 (16)	12	48
C	6/25	36	3.63 (11)	43	86	58	5.00 (15)	23	92
D	7/2	29	2.81 (9)	49	98	51	4.08 (12)	25	100
E	7/9	22	2.66 (7)	43	86	44	3.93 (11)	25	100
F	7/16	15	.38 (4)	50	100	43	1.65 (8)	25	100
G	7/23	8	.05 (2)	50	100	30	1.32 (6)	25	100
H	7/30					23	1.29 (5)	25	100
I	8/6					16	1.27 (4)	25	100

*The numbers in parentheses indicate the number of rains the checks and treated foliage received.

An interesting observation relating to temperature was noted in the dosage tests and also in the tests with deposits of various ages on orchard-sprayed foliage (see table). In several tests with *M. ancyliivorus* and *C. forbesi*, it was observed that more rapid and more extensive kill took place when the temperatures during the cage tests averaged close to 70° F. than in similar tests where the average temperature of the cages was 80° F. and higher. Further tests are needed to substantiate these unexpected results.

RESULT OF AGE-OF-DEPOSIT-TESTS.—In addition to the dosage and exposure time experiments, a series of tests with foliage sprayed at 7-day periods from June 19 to August 8 were conducted on July 2, 11, 16, 23, 30, and August 8 and 22, 1945. In these tests the adult parasites were exposed to the foliage from the orchard-sprayed trees coated once with DDT at the rate of a 1-1000 water suspension. During the season, *M. ancyliivorus* was available for all the test periods;

adults of other parasites, reared from the strawberry leaf roller, were available to July 20; and *A. apicifera*, collected from sweet clover, from July 30 to August 10.

In all of the age tests where average temperature during the test period did not exceed 72° F., 100 per cent of all of the adults of all the species were killed when exposed to DDT orchard-sprayed foliage 1 to 4 weeks old. In similar tests with *M. ancyliivorus*, 100 per cent kill took place with orchard-sprayed foliage 7 weeks old. If the temperature at the test period averaged 80° F. or higher, the percentage killed was reduced somewhat. Rainfall on the sprayed foliage apparently did not reduce sufficiently the toxicity of DDT to parasites to permit them to visit the treated foliage without some or complete mortality.

Individual peach trees were sprayed once with DDT at the rate of 1-1000 on the dates indicated. These trees received no further sprays or dusts during the entire season. The table shows the age of the sprayed foliage employed, the rains to which it was subjected, and the number and percentage of adults killed in two of the tests. Note that lower percentages of kill are recorded when the test was made at temperatures averaging 82° F. (July 31 test) than at temperatures averaging 68° F. (August 22 test).

SUMMARY

Tests were conducted on the effect of DDT on certain parasitic insects, particularly those attacking the oriental fruit moth (*Grapholitha molesta* Busck) and the strawberry leaf roller (*Ancyliis comptana fragariae* (Walsh & Riley)), to determine the strength of DDT and the exposure time required to kill and the toxicity of deposits 1 to 9 weeks old on orchard-sprayed foliage.

DDT was found to be exceedingly toxic to *Macrocentrus ancyliivorus* Roh., *Cremastus cookii* Weed, *Cremastus forbesi* Weed, *Nemorilla floralis* (Fall.), and *Archytas apicifera* (Walk.).

In all tests except one, 1 part of DDT to 10,000 parts of water killed 100 per cent of the adults of all five species. *Macrocentrus ancyliivorus* and *Archytas apicifera* showed total mortality at strengths as low as 1 part to 50,000.

DDT on peach foliage from the orchard sprayed at the rate of 1 part to 1,000 parts of water continued to be highly toxic for 4 to 7 weeks. In some tests with *Macrocentrus ancyliivorus* 100 per cent kill resulted when males and females were exposed to orchard-sprayed peach foliage at least 7 weeks after a single spraying with DDT.

CONCLUSIONS

The above laboratory tests indicate that DDT may prove to be toxic to adults of many species of braconids, ichneumonids and tachinids if they touch, walk or rest on plants in the field that have been sprayed with DDT for the control of insect pests. Briefly stated, biological control of some insects may be curtailed when DDT is used extensively.

LITERATURE CITED

- Peterson, A. 1934. A Manual of Entomological Equipment and Methods. Part I, Pl. 77, Figs. 5 and 6. Edwards Bros., Ann Arbor, Mich.